

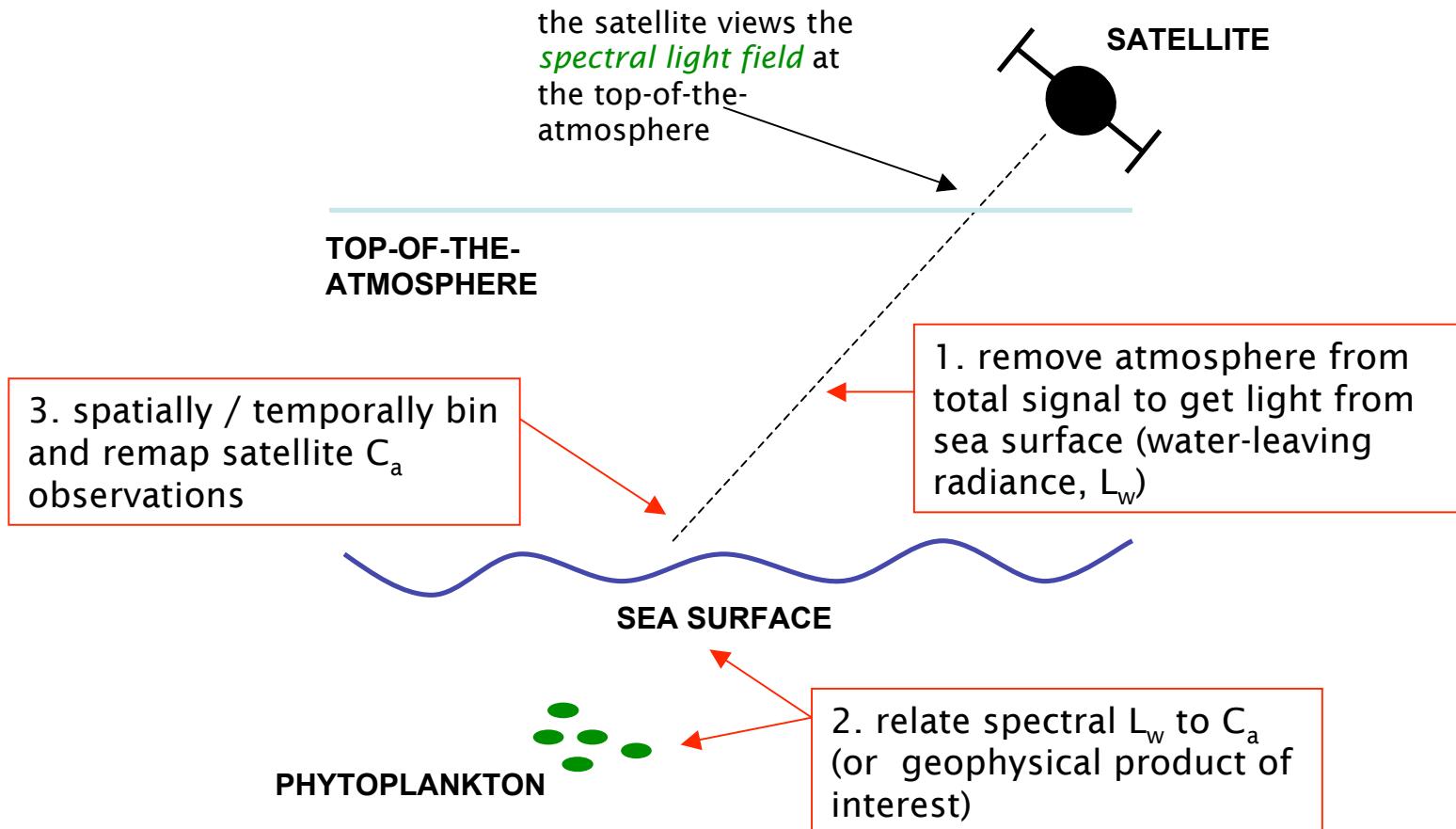
# Validating the GSM01 algorithm for chlorophyll products in the Chesapeake Bay

Mimi Szeto

Research & Discover, GSFC Summer Intern 2007

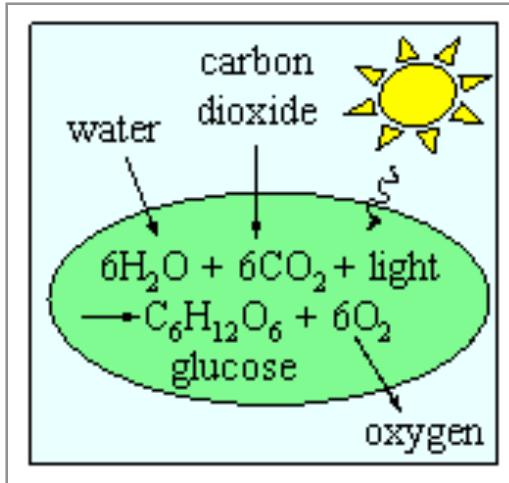
Advisor: Jeremy Werdell, 614.2

# Background: Remote Sensing

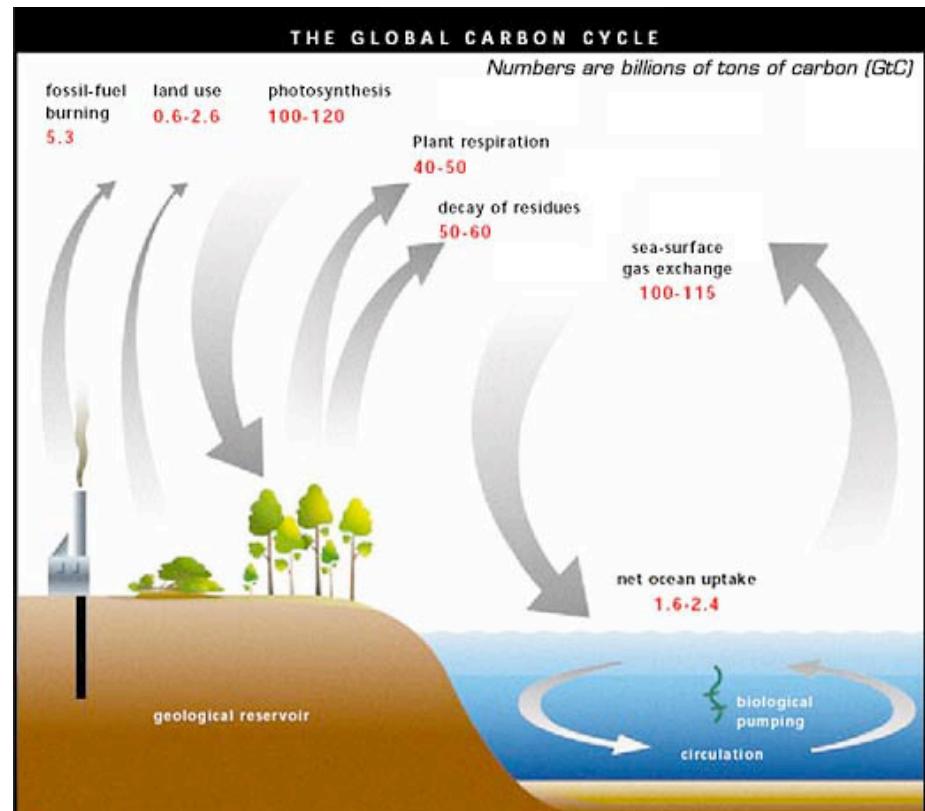


# Background: Why Chlorophyll?

## Photosynthesis in Chlorophyll



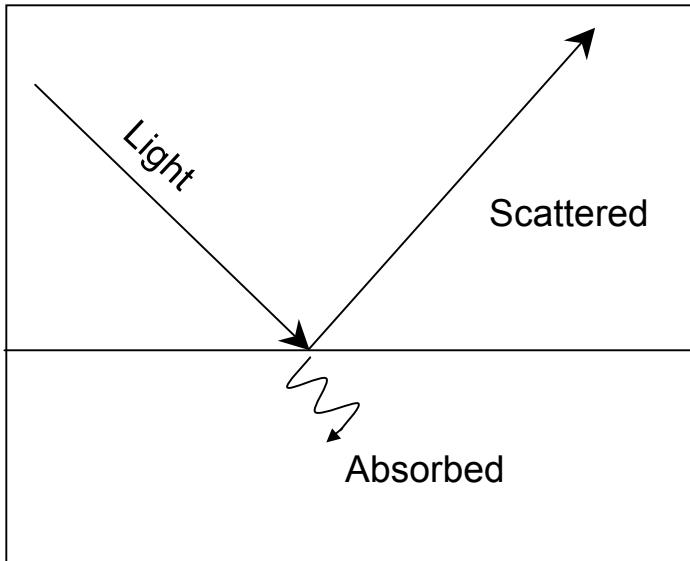
## Global Carbon Cycle



## Legal Action for Regulating Bay Health



# Background: How it works.



Remote Sensing Equation

$$R_{rs} = \text{fcn}\left(\frac{b_b}{a + b_b}\right)$$

Remote sensing reflectance,  
Derived from water leaving radiances

Inherent Optical Properties

# Background: How it works.

Remote Sensing Equation

$$R_{rs} = \text{fcn}\left(\frac{b_b}{a + b_b}\right)$$

Inherent Optical Properties

ABSORPTION

$$a = a_w + a_\phi + a_{dg}$$

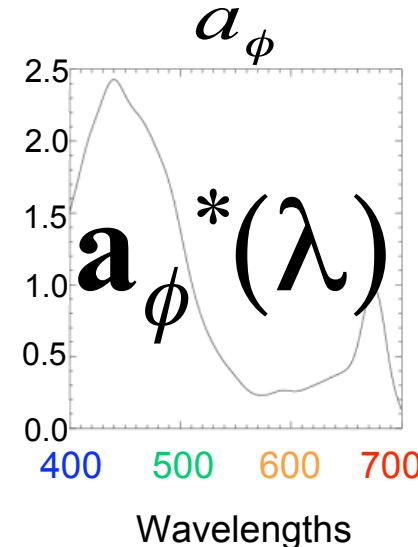
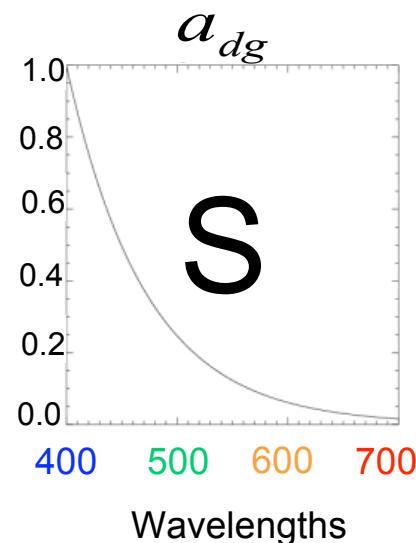
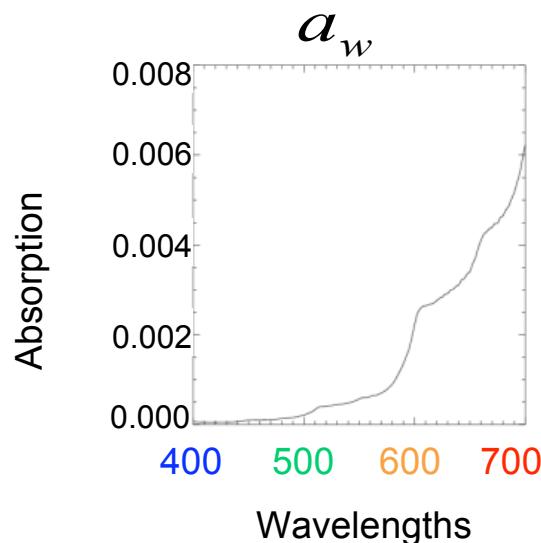
water      plankton      CDOM and non-algal particles

SCATTERING

$$b_b = b_{bw} + b_{bp}$$

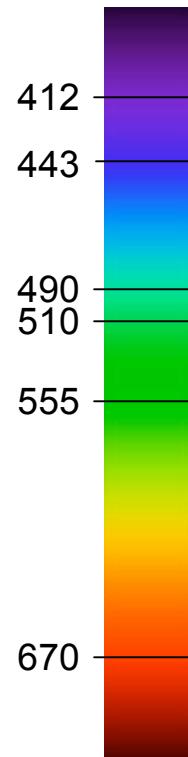
water      particles

Inherent Optical Property = [magnitude] x (spectral shape)



# Background: How it works.

SeaWiFS  
Wavelengths



412	$Rrs(412)=fcn(\text{magnitude}_{dg,\phi,b}, \text{spectral shape}(412)_{dg,\phi,b})$
443	$Rrs(443)=fcn(\text{magnitude}_{dg,\phi,b}, \text{spectral shape}(443)_{dg,\phi,b})$
490	$Rrs(490)=fcn(\text{magnitude}_{dg,\phi,b}, \text{spectral shape}(490)_{dg,\phi,b})$
510	$Rrs(510)=fcn(\text{magnitude}_{dg,\phi,b}, \text{spectral shape}(510)_{dg,\phi,b})$
555	$Rrs(555)=fcn(\text{magnitude}_{dg,\phi,b}, \text{spectral shape}(555)_{dg,\phi,b})$
670	$Rrs(670)=fcn(\text{magnitude}_{dg,\phi,b}, \text{spectral shape}(670)_{dg,\phi,b})$

Chlorophyll concentration      Model Parameters

# Background: *In situ* vs Satellite

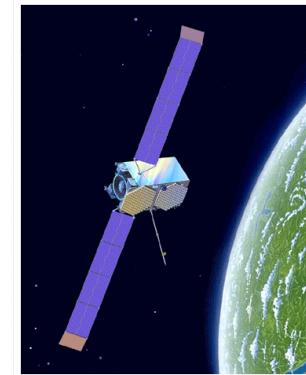
*IN SITU*



nLw: Radiometer

Chlorophyll: HPLC, fluorometer

SATELLITE



nLw



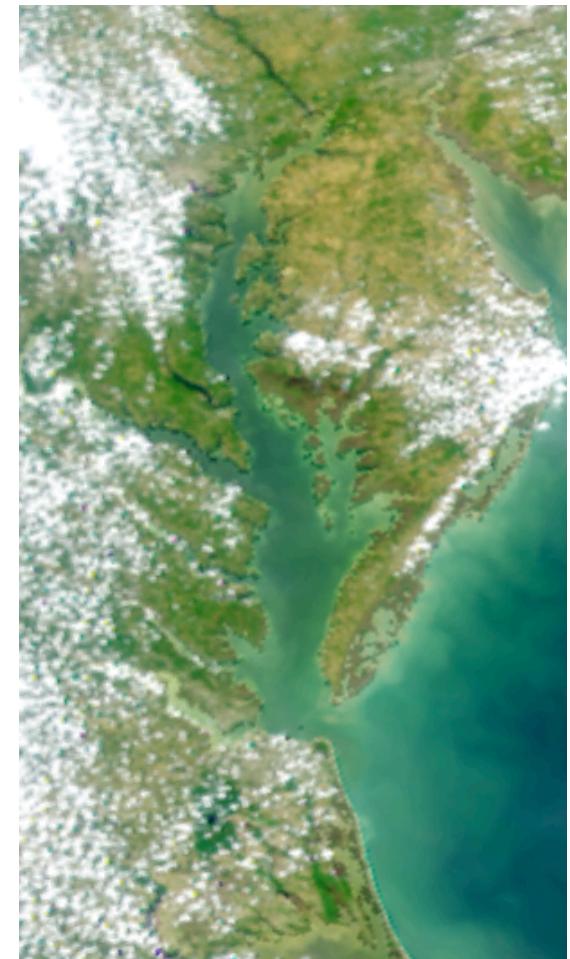
Chlorophyll

- NOMAD

- in situ data set (N: 2208, 281 in the Chesapeake Bay)
  - Chl Concentration, Rrs at SeaWiFS wavelengths
  - Modeled products vs In situ products

# GSM01

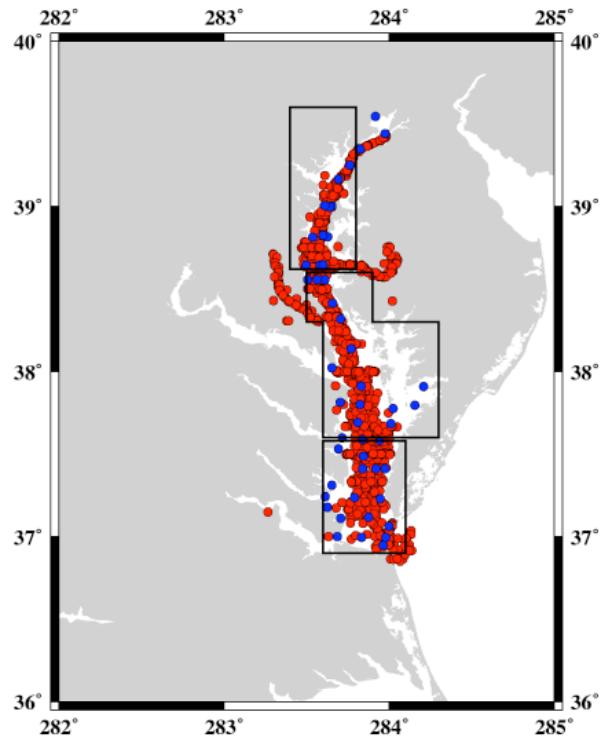
Algorithm	Developers	Model Parameters
GSM01	<b>Garver and Siegel, 1997</b> <b>Maritorena, 2002</b>	Global
GSM01CB	Magnuson, 2004	Regional and Seasonal



Season	Region
Spring	Upper
Summer	Middle
Fall	Lower

# Validation and Testing

- Consolidate data from 3000 stations.
- Statistically derive new model parameters



ABSORPTION

$$a = \cancel{a_w} + a_\phi + a_{dg}$$

water      plankton      CDOM and non-algal particles

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SCATTERING

$$b_b = \cancel{b_{bw}} + \cancel{b_{bp}}$$

water      particles

GSM01

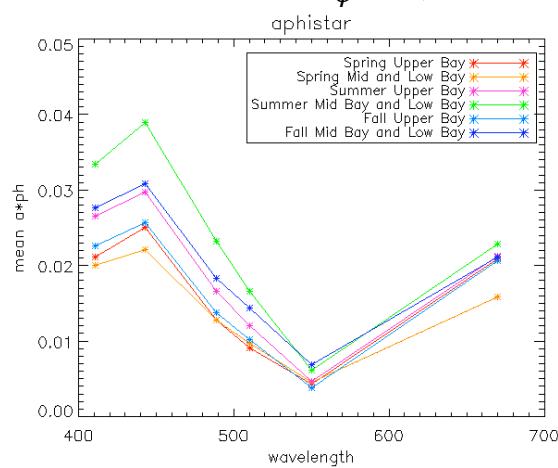
NOMAD Rrs

$a_\phi^*(\lambda) & S$   
Combo 1  
Combo 2  
Combo 3...

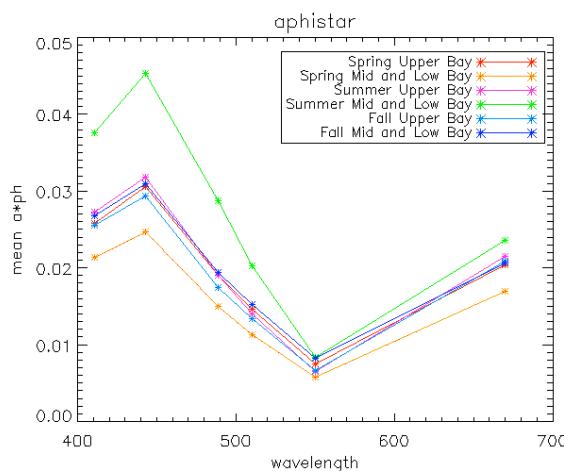
Modeled Chl 1  
Modeled Chl 2  
Modeled Chl 3 ...

# Results: Model Parameter

GSM01CB  $a_{\phi}^*(\lambda)$



New Parameter  $a_{\phi}^*(\lambda)$



Season-Region	GSM01CB S	New Parameter S
Spring-Upper	.01218	.01260
Spring-Middle	.01385	.01443
Spring-Lower	.01330	.01449
Summer-Upper	.01218	.01247
Summer-Middle	.01385	.01407
Summer-Lower	.01330	.01335
Fall-Upper	.01218	.01264
Fall-Middle	.01385	.01397
Fall-Lower	.01330	.01346

# Results: Chlorophyll Modeled/Insitu Ratio

(ACCURACY)

(SPREAD)

Algorithm	Mean Ratio of Modeled Chl/ Insitu Chl	Median Percent Difference
GSM01	1.99	75.77
GSM01CB	1.19	62.83
New Parameters	1.01	65.44

# Validation and Testing

- Extra tests
  - Sensitivity Analysis
    - Drop 412
      - atmospheric problem
    - Drop 670
      - often not reliable
  - Matrix Inversion
  - Backscattering Parameter



Negative Modeled Chlorophyll

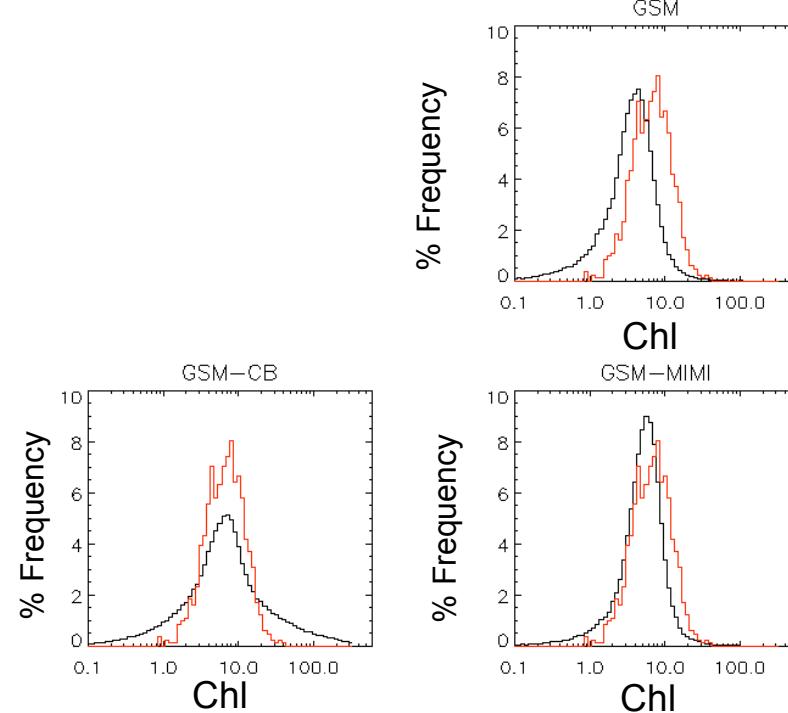
## RESULTS

Sensitivity Analyses, and Matrix Inversion	Mean Ratio	Median Percent Difference
New Parameters Without 411	1.86	71.81
New Parameters Without 670	1.11	47.27

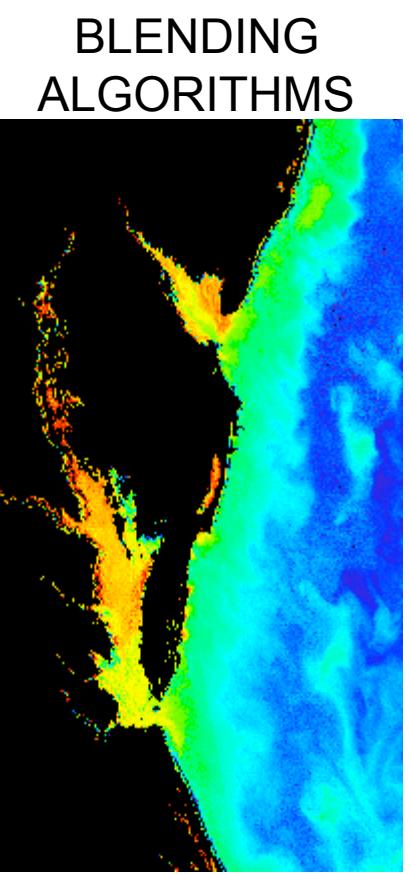
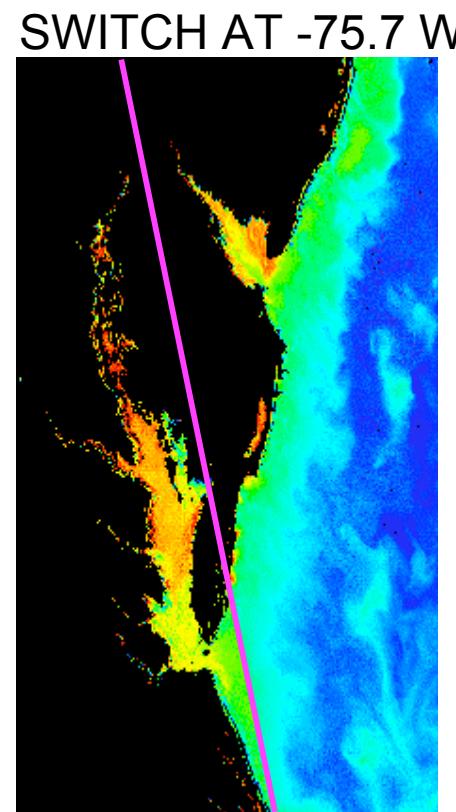
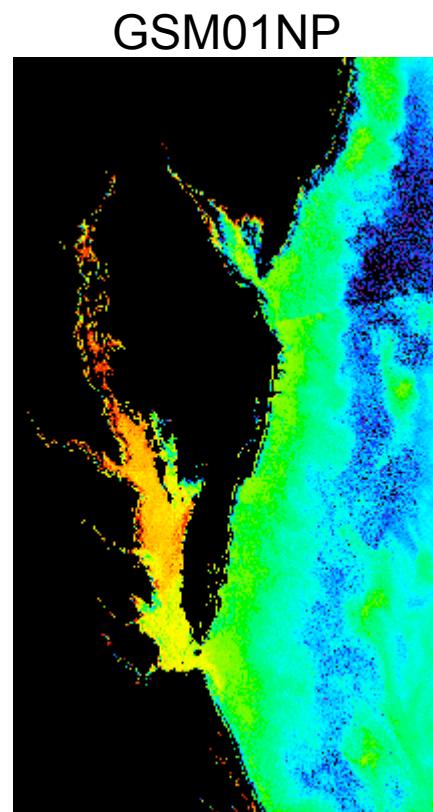
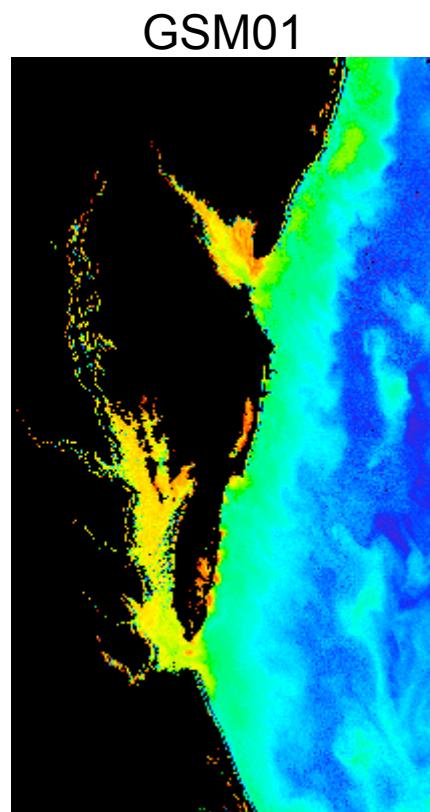
# Ten-Year Analyses

- Distributions of % Frequency for 10 years of Chl data
  - GSM01NP - ineffective in Summer
    - High values
  - Better in Fall

RED = *IN SITU* CHL  
BLACK = MODEL CHL



# Regional Blending

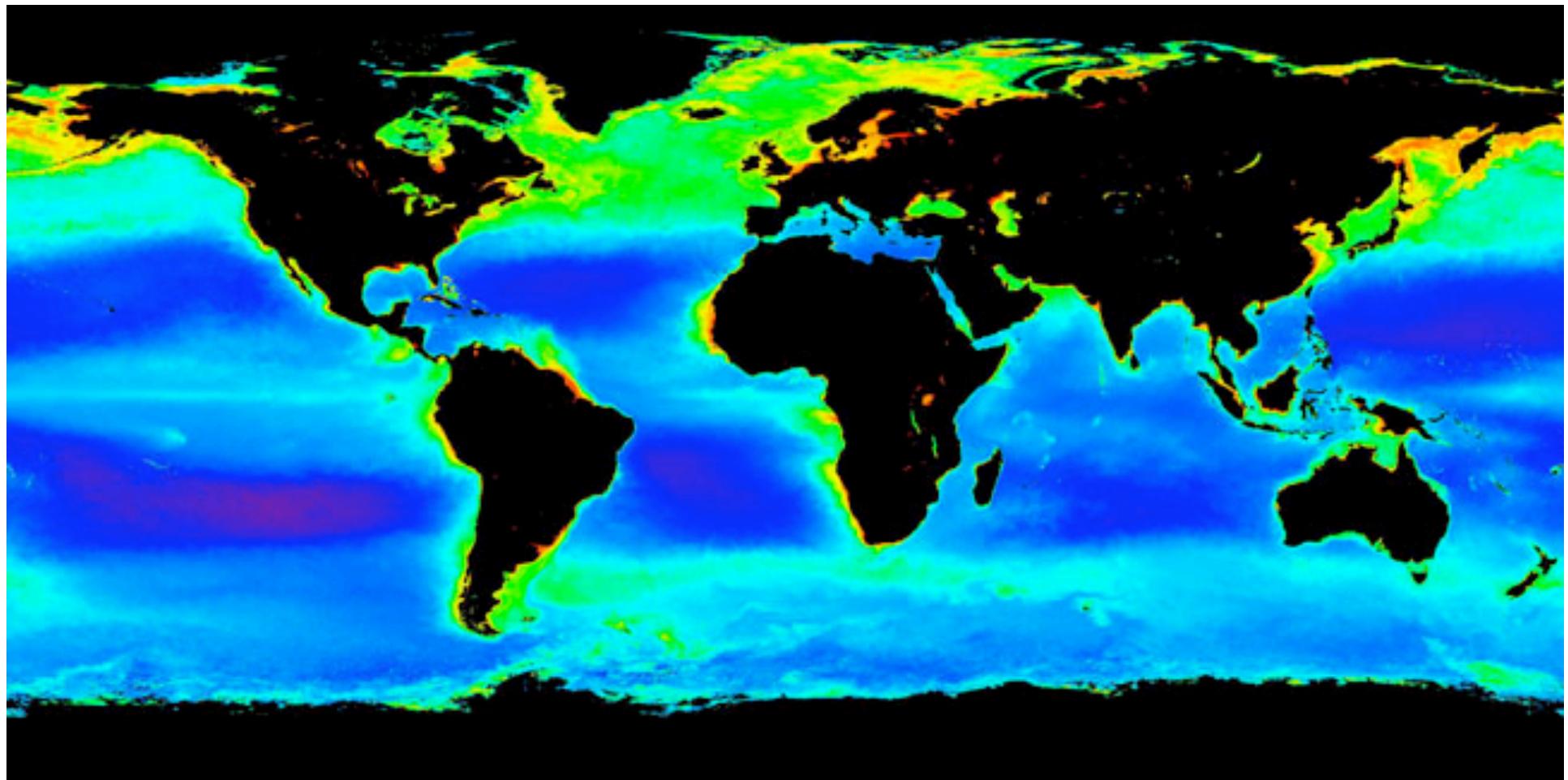


# Conclusion

- Validation was successful.
  - The new parameters help improve chlorophyll retrievals.
- I created a method for sensitivity analysis.
  - Use all six wavelengths with the new parameters.
- Blending algorithms can be used to avoid abrupt transitions in chlorophyll images

# Acknowledgements

- Jeremy, Sean, Gene, Brian, and the rest of the Ocean Biological Processing Group at NASA
- Research and Discover, UNH
- Fellow interns



# Ten-Year Analyses

Ten Year Time Series Comparison of Modeled Chlorophyll vs Insitu Chlorophyll

